A Sedimentological Study of
KAIMUR AND REWA SANDSTONES
Around Chanderi, Madhya Pradesh.

BY

SHEO PRASAD
M. Sc. (Final)

THESIS SUBMITTED IN LIEU OF PAPER IV
FOR
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CHAPTER I

I N T R O D U C T I O N

CHAPTER I

INTRODUCTION

The Vindhyan rocks occupy a very important position in Indian stratigraphy. The term Vindhyan was first of all introduced by Geological Survey of India to the scarped ranges along the north side of Narmada Valley and was employed by Oldham (1856) to designate the great sandstone formation of Bundelkhand and Malwa.

Various workers have done work on different areas of Vindhyan, but the sedimentalogical study of Chanderi has not so far been attempted. Keeping it in mind, the area was selected for sedimentalogical studies.

Chanderi is situated between longitudes of 78°5' and 78°15' and latitudes 24° and 24°45' in Guna district, Madhya Pradesh.

Sedimentalogical studies were carried out under the following heads:-

(1) Field work including the mapping, collection of samples and measurements of sedimentary structures.

(2) Laboratory work including the construction of palaeocurrent map with the help of directional sedimentary structures, the appositional fabric studies, petrographic studies of rock types, size frequency distribution of elastic units of upper Vindhyan, their characteristics and possible use to decipher the envieronment of deposition.

From the mineralogical and textural investigations combined with directional structures, the probable source area, the nature of transporting agent and the depositional environments were determined.

The area was geologically mapped in the month of September 1966 by out crop walking method with the help of clinometer compass. An area of about 64 square miles in and arround Chanderi was covered and representative samples were obtained from the field. Since the parts of the area are covered by alluvium and forests, it was impossible to follow any regular grid pattern of sampling. However, all the Nallahas, river cuttings and road cuttings apart from the scarp of hillocks were visited and representative specimen of sandstones were collected.

In the area of investigation the primary structures are not developed profusely hence few observations of cross beddings, ripple marks and parting lineations could be made. Since the data was inadequate for palaeocurrent study, the appositional febric study of quartz grain with an elongation ratio of 2 : 1 or more was done in the laboratory using oriented specimen brought from the field. With the help of directional sedimentary structure and appositional fabric, palaeocurrent directions were obtained and plotted on the map.

The modal analysis of the sandstones was performed in order to determine their mineralogical composition and also to classify them according to modern terminology.

Since the rocks were hard and well cemented, the method of sieving could not be applied. However, thinsection size analysis following the method outlined by Friedman(1958), was carried out. The statistical paramenters were calculated from the cumulative curves using the method outlined by Sahu(1964)

The parameters, phimean diameter, phi standard deviation, phi deviation, phi skewness and phi kurtosis were determined and the environment of deposition calculated.

ACKNOWLEDGEMENTS- I feel a great pleasure to acknowledge my deep gratitude to professor F.Ahmad Head of Department of Geology, Aligarh Muslim University, Aligarh, who very kindly gave me full facilities for carrying out my work. I am also indebted to Dr. V.K.Srivastava, who in the midst of his multifarious duties spared time to give instructions and guidance to me.

My grateful thanks are due to sarvasri A.T.Balgopal and B.D.Bharadwaj, Research scholars, Department of Geology, Aligarh Muslim University, Aligarh, who, from time to time, helped and favoured me with their valuable suggestions.

CHAPTER II

M E T H O D S A N D T E C H N I Q U E S

CHAPTER II

METHODS AND TECHNIQUES

PALAEOCURRENT STUDIES- In the area of investigation all the available ripple marks, parting lineations and cross beddings were measured. The primary structures were utilized in the construction of a palaeocurrent map.

At different localities in the area 30 measurements of symmetrical ripple marks were taken. The amplitude and wavelength of each ripple mark were measured with the help of scale. The strike of ripple axes were measured keeping the clinometer compass parallel to the strike of ripple axis. The average of these ripple strike in respect of each locality was calculated. As the strike of ripple axis is perpendicular to the direction of sediment transport, the direction of palaeocurrent at the given locality has been shown perpendicular to the strike of ripple axis in the map. Besides this, the average of measurements in respect of Kaimur and Rewa were calculated separately and plotted as circular histograms in 20° class interval as shown in the map and Fig. 6 & 7

The foresets of the cross beds were measured in the field with the help of clinometer compass. In many cases the cross bedding plane itself was available and in such cases direct measurements were made on the dip azimuths. However, in cases where such planes were not available, apparent dips on two non parallel phases were measured and the true dip and azimuth was ascertained using a steriographic net.

Parting lineation is absent in Rewa sandstone and is rare in Kaimur sandstone in and around Chanderi. The palaeocurrent directions were measured from different lacalities, keeping the clinometer compass parallel to the lineations. Nearly 12 measurements were made and the average of current direction obtained inrespect of each locality has been plotted locality wise. An average of all the readings obtained from Kaimur sandstone was also determined and plotted in 20° class interval in a rose diagram as shown in Fig.7

GRAIN ORIENTATION - Oriented sample of Kaimur and Rewa sandstones were collected from the area for grain orientation study.

The oriented thin sections were cut parallel to bedding. Parallel lines were drawn very closely on the slide in north South direction. The thin section was so adjusted on the stage of microscope that these lines and the vertical cross wire were parallel to the marked North-South direction on the graph paper.

After necessary adjustment, 200 elongated quartz grains were selected from each slide and drawings were made with the help of camera lucida. The orientation of grains were measured, and the measured orientation was plotted in a rose diagram in 20° class interval. The vector mean was also calculated and plotted following the method out lined by Curray (1956). Thus in all 10 slides were studied and the obtained palaeocurrent directions were plotted on the map. For determining the general palaeocurrent direction of Kaimur and Rewa separately, two rose diagrams one for Kaimur another for Rewa were made from their average readings separately. Their vecter mean were also determined and marked accordingly as shown on the map and in Fig.

MODEL ANALYSIS - The sandstones were studied in hand specimen as well as under microscope for petrographic purpose and for determining the percentage of mineral constituents present in Kaimur and Rewa sandstones. Modal analysis of Kaimur and Rewa sandstones were done with the help of swift point counter, Nearly 500 grains were counted from a thin section to determine the percentage composition of the rock by volume. Seventeen thin sections were studied in a detailed manner and their mineralogical compositions were plotted in a triangular diagram following Hubert (1960).

SIZE ANALYSIS - The rocks are hard and compact due to silica cementation and attempts to disaggregate the sandstones failed. The size analysis was therefore performed from thin sections following the method outlined by Friedman (1958). The thin section was mounted on the mechanical stage and the length of the grains were measured using a micrometer occular. 200 grains were measured from each section. Nearly 2,000 grains were measured from different horizons. The millimetre measurements were converted into phi units and classified into various grades. The size frequency distribution was graphically represented in the form of histograms. Cumulative curves were constructed and equivalent parameters of sieve analysis were determined using Friedmans (1958) graph, ϕ5, ϕ 16, ϕ 25, ϕ 50, ϕ75, ϕ 84, ϕ 95 were determined. From the various percentiles the statistical parameters after Sahu (1964) were calculated.

CHAPTER III.

PREVIOUS WORK AND GEOLOGY OF THE AREA.

CHAPTER III

PREVIOUS WORK AND GEOLOGY OF THE AREA

The Vindhyan system of India is a sequence of unfossiliferous rocks. In recent years however, some discoid impressions have been reported from the Suket Shale of Rampura. About the nature of these impressions, there is a difference of opinion. According to some workers they are organic while others, consider them to be inorganic.

The Vindhyans are essentially unmetamorphosed and undeformed. They are composed mainly of Orthoquartzites, limestones and shales and form the hill ranges of Madhya Pradesh, Rajasthan and Southern Uttar Pradesh.

Captain Franklin (1928) studied a portion of Bundelkhand district and described some of the sandstone sections observed in Rewa plateau. Oldham (1956) opined that the sandstone of Bundelkhand is of a different character and belongs to a more older age than the beds of Central India and Bengal which are associated with coal. Mallet (1869) mapped the Vindhyans of Central India followed by Oldham, Vrendenbarg and Dutta(1901) who mapped the Mirzapur district in great detail, giving a good account of stratigraphic information along with the features of the process of Vindhyan sedimentation. In recent years more work has been done on the Vindhyan rocks of Mirzapur, Maihar and Rajasthan, but the study of Chanderi area has not been attempted so far.

The area was geologically mapped by the author with the help of clinometer compass. An area of about 64 Sq. miles in and around Chanderi was covered.

In the area the following sequence is observed :-

Rewa sandstone

Rewa Shale

Kaimur sandstone

~~~~~~~~profound unconformity

Bundelkhand granites and gneisses

The Bundelkhand complex forms the basement over which the Vindhyan rocks were deposited. In the area of investigation the complex consists of granites, mostly weekly foliated, but true gneisses are absent.

The Vindhyan rocks rest over the granites with a distinct unconformity. Clearly there is an overlap in this area because the Kaimur rocks (upper Vindhyan) rest directly over the granites and the rocks of Semri group do not occur between them. There are numerous outliers of Kaimur sandstone in the area.

The Kaimur sandstone is yellowish or pinkish in colour. The Kaimur sandstone is distinguished from the Rewa sandstone by its greater purity, more quartzite like character, thin bedding and more marked tendency. It is hard and medium to fine grained, the grain size varying from 0.5 mm to 0.31 mm. Ripple marks are abundant at certain horizons and so are also parting lineations, but cross bedding is not very abundant.

The general strike of Kaimur sandstone is N.W. to S.E. and dips generally vary from 3° to 8°. The dip direction is generally westerly.
~~~~~~~~

At Mongara the dips are very high. The amount of dip varies from 5° to 40° and a strike fault has been observed with a lateral movement of 250' along the fault plane.

The Rewa shales are thin bedded varying in colour from greyish to yellowish. The shales are often intercalated with very thin sandstone beds and occupy low lying areas.

The Rewa sandstone is whitish brown in colour thick bedded less hard and quartzite more impure than Kaimur sandstone. Ripple marks are also found im Rewa sandstone,but cross bedding-s are rare and parting lineations are absent.

The general trend of strike is North West to South East and the amount of dip varies from 3° to 8° generally in the South West direction. The beds are almost horizontal at places but at Imalia the dips are high due to folding of the strata.

CHAPTER IV.

P E T R O G R A P H Y .

CHAPTER IV

PETROGRAPHY.

Micropetrology

KAIMUR SANDSTONE - Kaimur sandstone is yellowish or pinkish brown in colour. It is hard and medium to fine grained. The grain size varying from 0.5 mm to 0.3 mm.

In thin section the frame work of the rock is seen to be composs͛ed of quartz, chert, feldspar, rock fragments and accessories which are cemented by either iron oxide or secondary silica. The silica cement has been counted along with the quartz grain. The quartz grain are well rounded and show secondary over growth in optical continuity with detrital grains. Their percentage varies from 86 to 97 by volume. Atplaces over growths are very irregular and some times give rise to angular outlines to the grains (Plate 1 and 2,Fig.10). In some grains it becomes difficult to distinguish between the deterital grain and the over growth but at places where the grains are surrounded by the thinfilm of iron oxide, the boundary between them becomes very clear.

Two types of quartz grain are found namely, one that show strain shadows indicating metamorphic derivation and the other showing inclusions etc. indicating igneous character. Suture contacts between grains are also present which indicate penetration of one grain into the other (Plate 3,Fig.10).

Table1- Modal composition of Kaimur sandstone(percent by volume).

Sl. No.	Constituents / Sample No.	Quartz and silica cement	Chert	Rock fragment	Feldspar	Accessary	Ferrugenous cement
1.	85	92.8	4.4	1.4	-	1.2	0.2
2.	86	92.4	3.8	1.4	-	1.6	0.8
3.	64	91	2.8	1.2	-	5	-
4.	47	93.6	1.8	1.8	-	2.6	0.2
5.	34	91	5	1.8	0.4	1.8	-
6.	16	97	1.6	0.6	-	0.4	0.4
7.	50	86.6	10.2	0.4	-	2.6	-

Two types of chert are found to occur in these rocks. One variety is detrital in origin while the other occurs in the inter spaces as a chemical precipitate (Plate 3, Fig. 10). The amount of detrital chert is greater than the chert present in inter spaces. These grains are sub rounded to rounded and somewhat bigger in size than the quartz grain. The percentage of chert varies from 1.6 to 10.2 by Volume.

Rock fragments occuring in the sandstone are of metamorphic quartzites. These fragments vary from 0.4 to 1.8 percent by volume of the rock. Rock fragments are well rounded and a bit larger than the quartz grain.

Feldspar are generally absent and, if present, their amount is very nominal.

Accessories,too, are present in a very small quantity the percentage of which does not exceed 5.

Cements in Kaimur sandstone comprise Silica and ferrugenous precipitates due to the textural maturity of the rock and the presence of over growths, it is often imposible to dintinguish between the boundary of detrital grains and the silica cement Hence silica cement was counted along with the quartz grains.

The above study shows that the Kaimur sandstone is texturally and compositionally very mature and consists almost entirely of quartzose material. The problem of classification, therefore, does not arise in this case because whichever system of classification is adopted, the Kaimur rocks fall under the group of " Orthoquartzites " or " Quartzose sandstone ".

REWA SANDSTONE - Rewa sandstone is whitish brown in colour. It is hard and medium grained. The grain size varies from 0.5 mm to 0.31 mm.

In thin section the frame work of the rock is composed of quartz, chert, feldspar, rock fragments and accessaries. The constituents of the frame work are cemented by either iron oxide or secondly silicia. The silicia cement has been counted along with the quartz grains because their differentiation was not possible in every case.

The detrital grains are generally of unequal size, and bigger grains are surrounded by smaller ones giving rise to moderate sorting. Most grains are subrounded to rounded.

Table,2- Modal composition of Rewa sandstone(percent by volume).

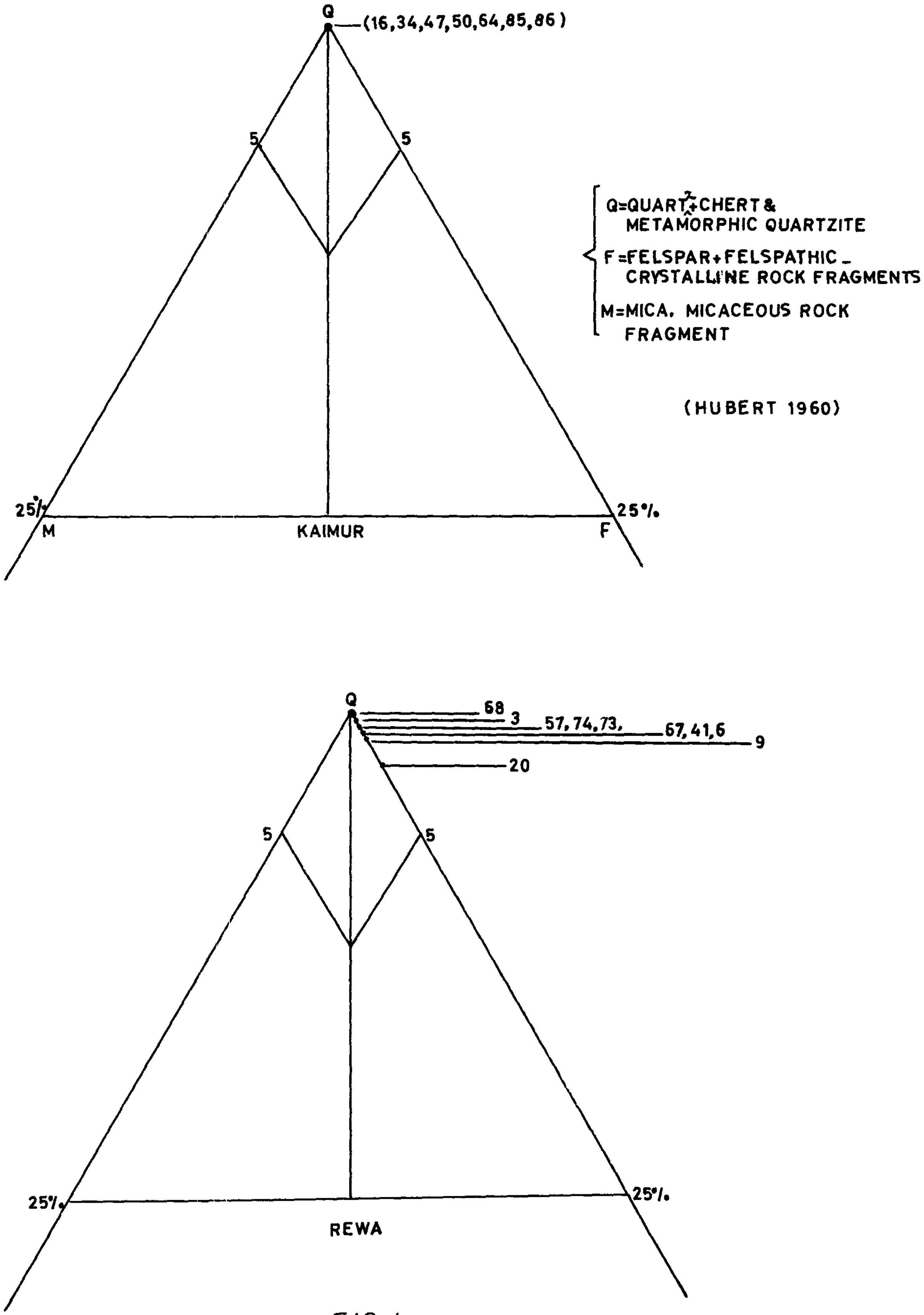
Sl. No.	Constituents / Sample No.	Quartz and silica cement.	Chert	Rock frag ment	Feldspar	Acce ssary	Ferru- genous Cement
1.	6	90.1	5.6	1	1.8	0.6	0.4

Table3- Modal composition of Rewa sandstone (percent by volume).

Sl. No.	Constituents / Sample No.	Quartz and silica cement	Chert	Rock fragment	Feldspar	Accessary	Ferrugenous cement
2.	20	94.6	1.6	0.8	0.6	2.4	-
3.	41	91.2	5.8	0.8	1.6	0.6	-
4.	57	87.8	6.8	2.6	2.4	0.4	-
5.	67	93.6	3.8	1.8	0.2	0.6	-
6.	68	94.8	1.2	1.4	2.4	-	0.2
7.	70	89.2	4.2	1.8	3.6	1	0.2
8.	73	93.6	2.4	1	2.6	0.4	-
9.	74	95.0	1.2	0.8	2	0.4	0.6
10	3	89.2	5.6	1.4	1.6	2	0.2

The percentage of quartz grain plus silica cement varies from 86 to 95 by volume.The quartz grains are cemented with silica which is present in the form of secondary overgrowth. The overgrowth is present in optical continuity with the detrital grains but is not very prominent in Rewa sandstone. However, ~~that~~ in some cases the overgrowth is so irregular that it imparts and angular shape to the grain (Plate 4, Fig. 11). Iron oxide is also present in the form of thin film, thus marking the overgrowth clearly from the detrital grains.

Two types of quartz grains are found. One type of quartz grain show strain shadows, indicating matamorphic origin while the other show some inclusions indicating igneous derivation. The presence of both the types of quartz indicates that igneous as well as metamorphic rock constituted the provenance of the



Q
(16,34,47,50,64,85,86)
5
5
Q=QUARTZ+CHERT &
METAMORPHIC QUARTZITE
F=FELSPAR+FELSPATHIC
CRYSTALLINE ROCK FRAGMENTS
M=MICA. MICACEOUS ROCK
FRAGMENT
(HUBERT 1960)
25%
25%
M
KAIMUR
F
Q
68
3
57, 74, 73,
67, 41, 6
9
20
5
5
25%
25%
REWA

FIG. 1

Rewa sandstone. Further the presence of second cycle quartz shows that the mature quartzose sandstones were also present in the source area.

Chert 1.5 % to 5.8 % the miscrocrystalline form of silica, also occurs in these rocks and consists of two types as in the Kaimurs. The detrital grains are sub-rounded to rounded. In Rewa sandstone the amount of chert in the interspaces is greater than the amount of detrital chert.

Rock fragments are those of metamorphic quartzite. The fragments vary from 1.5 % to 5.8 % by volume.

Feldspar are present in small quantity which varies from 0.4 % to 2.5 % by volume. Feldspar grains are also of the same size and shape as seen in the Kaimurs. Microcline and plagioclase are generally present among feldspar (Plate 5 , Fig. 11).

Accessaries are also present in small quantity and are sub rounded. Rutile, zircon and tourmaline are common but their total amount is small and does not exceed 0.4 % by volume of the rock.

The model composition of the rock shows that it is an Orthoquartzite.

Size Analysis

The size frequency distribution of the Kaimur sandstone has been graphically represented in the form of histograms in Fig. 2.

A review of the histograms shows that the Kaimur sandstone is characterised by a unimodel size frequency distribution. The model class lies in the fine sand grade ($\frac{1}{4}$ to 1/8 mm) and is quite

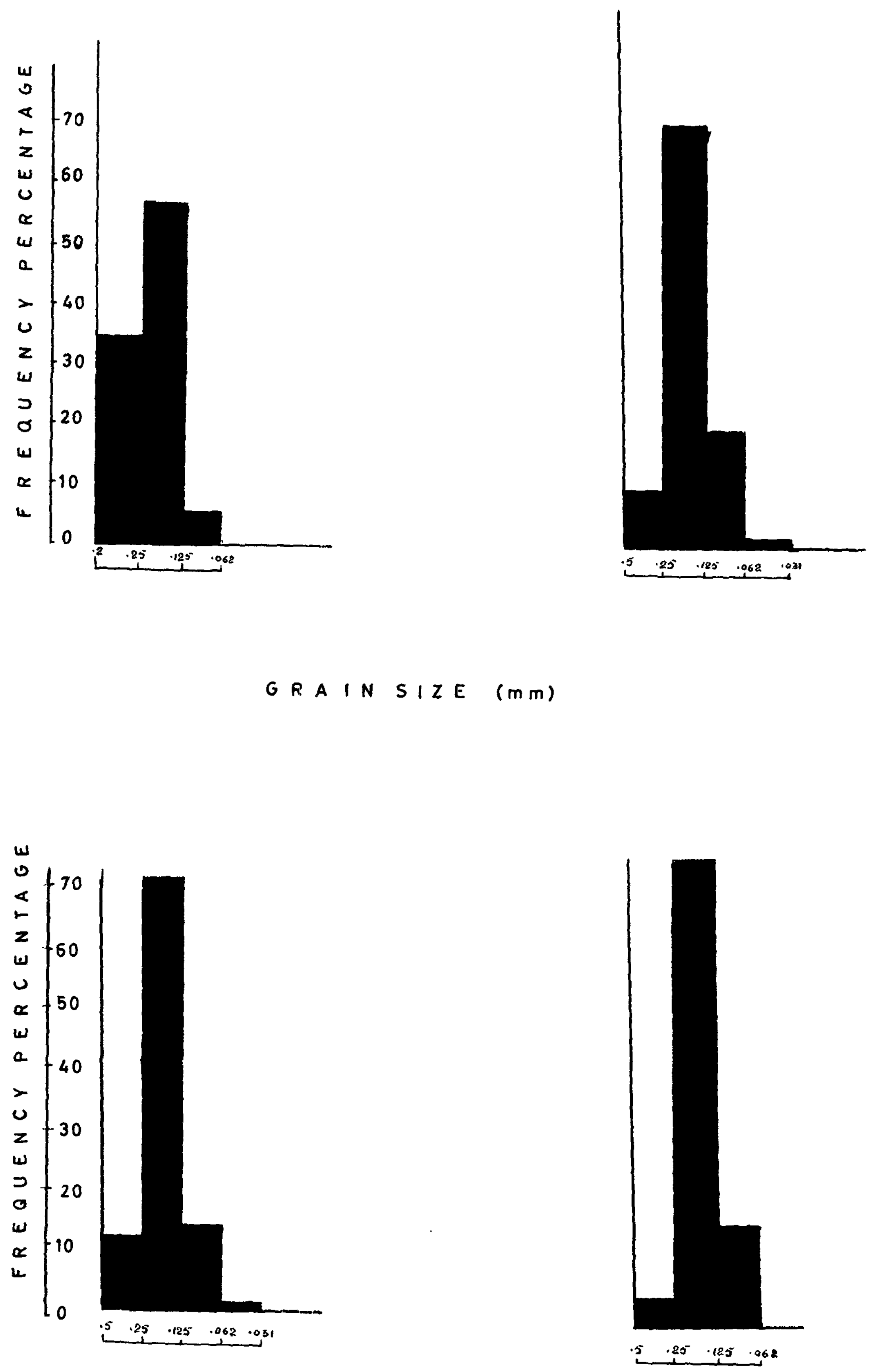


FIG. 2 HISTOGRAMS SHOWING THE MECHANICAL COMPOSITION OF KAIMUR SANDSTONE BASED ON THIN SECTION ANALYSIS

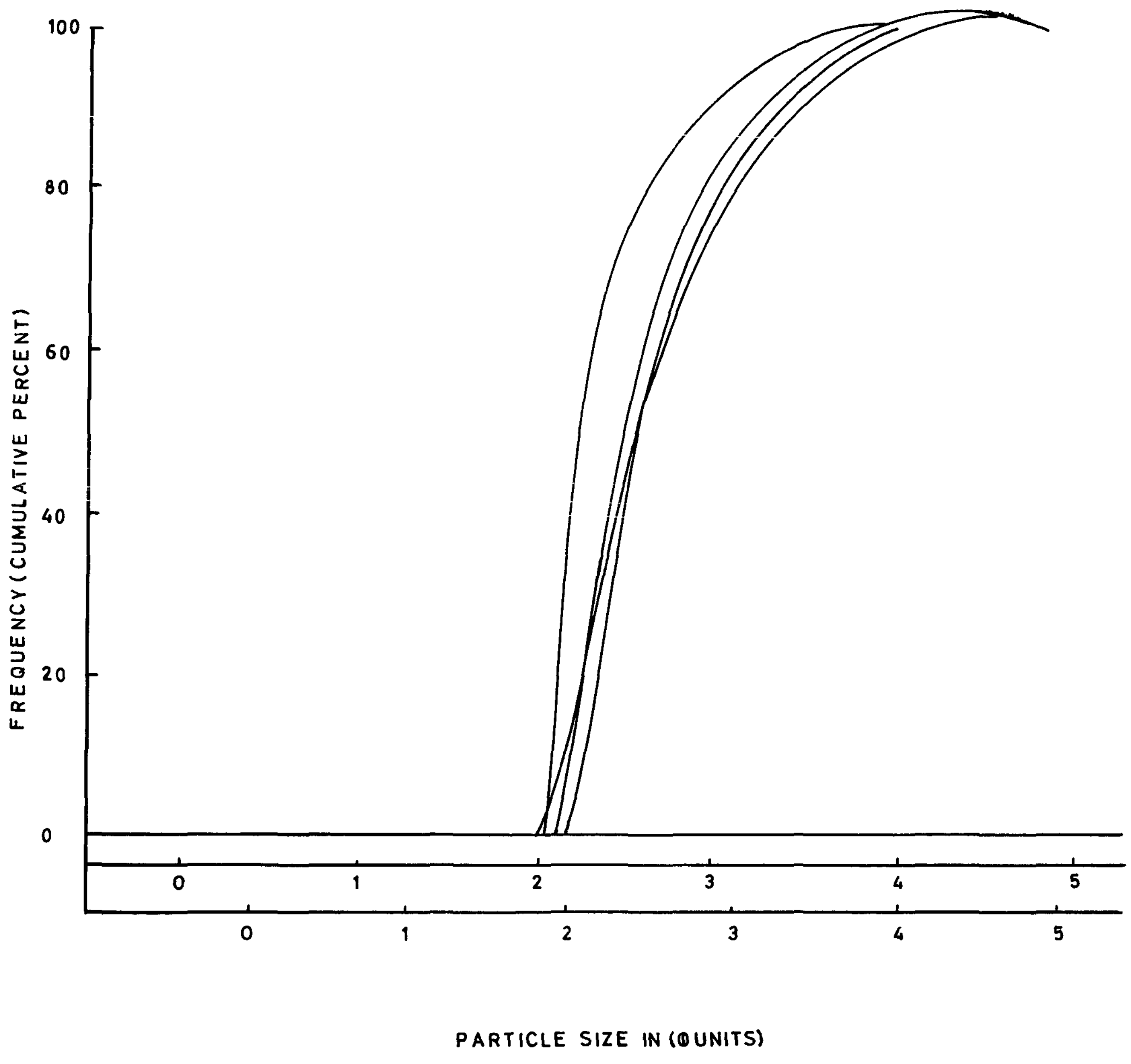

100
80
60
40
20
0
FREQUENCY (CUMULATIVE PERCENT)
0
1
2
3
4
5
0
1
2
3
4
5
PARTICLE SIZE IN (Ø UNITS)

FIG. 3

prominent. The fine admixture exceeds the coarse and therefore the distribution is slightly towards right, i.e. it is positively skewed. The sorting of the grains is moderate to good.

Fig. 3 shows the size frequency distribution of the Kaimur sandstone in the form of cumulative curves drawn in phi scale. The statistical parameters of the size frequency distribution in terms of quartile measures is shown in table -

Table 4 - Statistical size parameters of the Kaimur sandstones.

Sl No	Slide No.	Locality	$\phi 5$	$\phi 16$	$\phi 25$	$\phi 50$	$\phi 75$	$\phi 84$	$\phi 95$	Md	Mz	σ_I	Sk1	Kg
1.	34	Pirampur	2.1	2.15	2.15	2.3	2.55	2.8	3.25	2.3	2.41	.33	1.13	1.18
2.	47	Garhpichwara	2.15	2.25	2.35	2.65	3	3.25	3.75	2.65	2.68	.49	.77	1.00
3.	64	Singhpur Mahal	2.15	2.2	2.25	2.5	2.85	3.15	3.7	2.5	2.61	.47	.43	1.06
4.	86	Gurila Hillock	2.2	2.3	2.35	2.6	2.95	3.1	3.65	2.6	2.6	.41	.35	.99

The size frequency distribution of Rewa sandstone has been represented in the form of histograms in Fig. 4.

A review of the histograms shows that the Rewa sandstone is characterised by a unimodel size frequency distribution. The model class lies in the fine sand grade(1/8 mm to 1/16 mm) and is quite prominent. The fine admixture exceeds the coarse and therefore the distribution is slightly skewed towards right, i.e. it is positively skewed. The sorting of the grains is moderate to good.

Fig. 5 shows the size frequency distribution of the Rewa sandstone in the form of cumulative curves drawn in ϕ scale. The

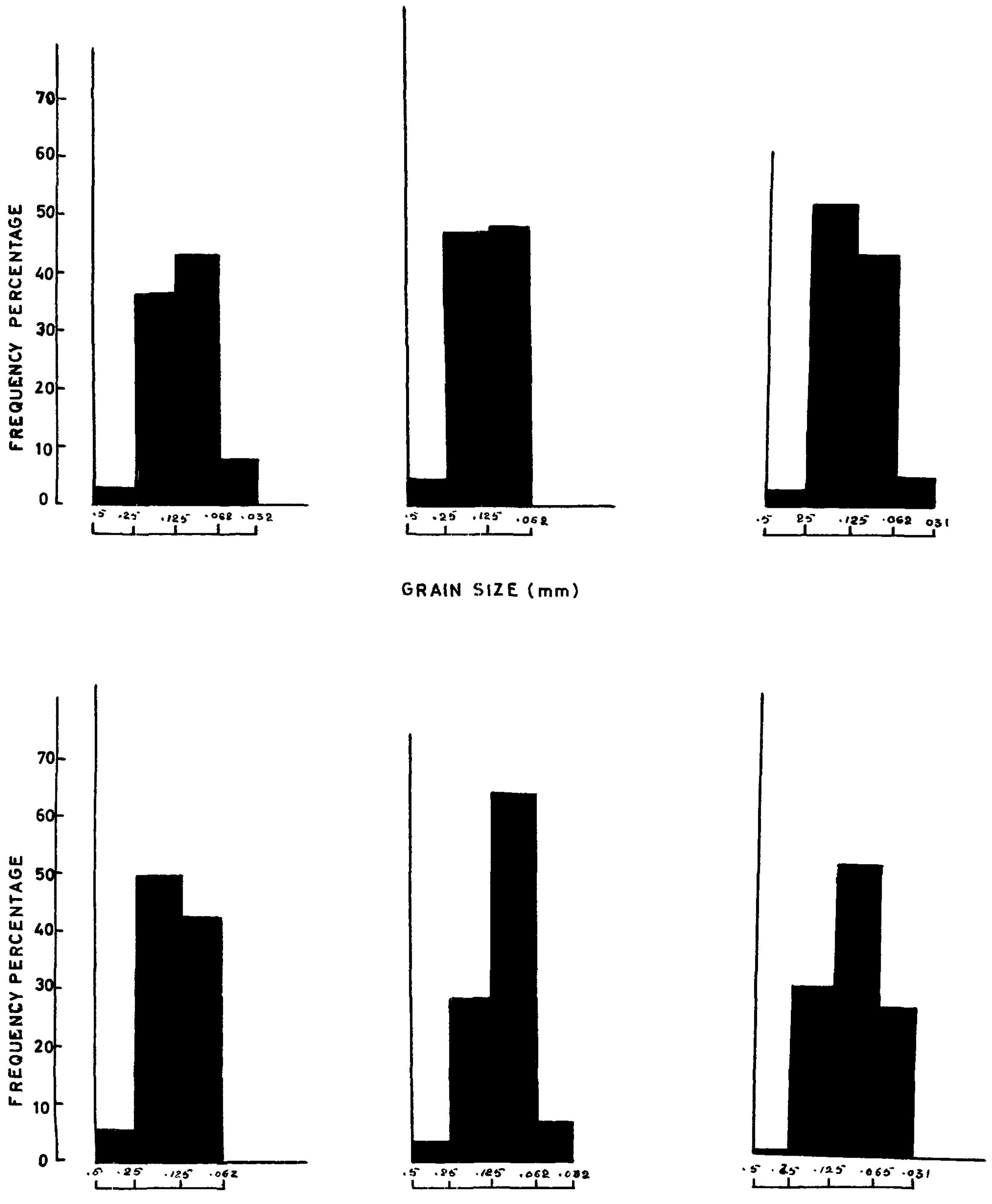


FIG. 4 HISTOGRAMS SHOWING THE MECHANICAL COMPOSITION OF REWA SANDSTONE BASED ON THIN SECTION ANALYSIS

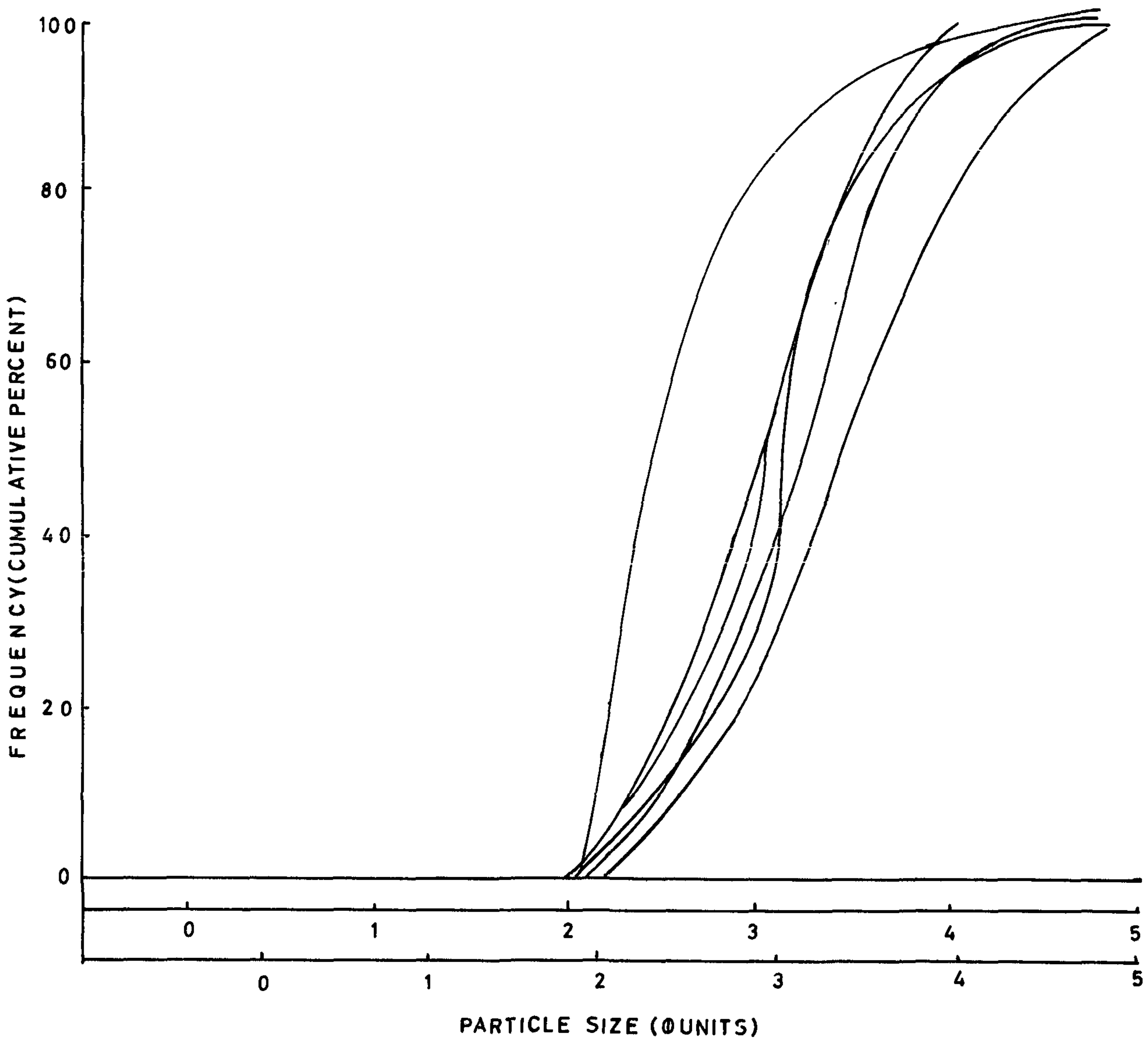

100
80
60
40
20
0
FREQUENCY(CUMULATIVE PERCENT)
0 1 2 3 4 5
0 1 2 3 4 5
PARTICLE SIZE (ΦUNITS)

FIG. .5.

statistical parameters of the size frequency distribution in terms of quartile measures is shown in table -

Table5- statistical size parameters of Rewa sandstones.

Sl No	Slide No.	Locality	φ5	φ16	φ25	φ50	φ75	φ84	φ95	Md	Mz	σ_1	Sk1	Kg
1.	3	Imalia	2.3	2.65	2.9	3.3	3.65	3.8	4.15	3.3	3.25	0.56	.105	1.01
2.	35	Singhpur	2.2	2.25	2.55	3.15	3.35	3.55	3.85	3.15	2.98	.57	-.26	.845
3.	41	Kaushak Mahal-to Chanderi	2.25	2.55	2.7	3.1	3.45	3.65	4	3.1	3.1	.53	.59	.94
4.	57	Marbawli	2.3	2.55	2.65	3.15	3.45	3.65	4.05	3.15	3.11	.54	.59	.89
5.	68	Muria	2.3	2.65	3	3.2	3.45	3.7	4.2	3.2	3.18	.54	.105	1.7
6.	74	Majhera	2.45	2.8	3.05	3.5	3.9	4.15	4.55	3.5	3.48	.65	.018	1.01

CHAPTER V.

PRIMARY STRUCTURES AND PALAEOCURRENT ANALYSIS.

CHAPTER V

PRIMARY STRUCTURES AND PALAEOCURRENT ANALYSIS

Primary structures are those that are formed during the process of sedimentation and are helpful in determining the direction of sedimentary transport and nature of depositional environment.

RIPPLE MARKS - Ripple marks refer to rhythmic periodic undulation and that occur on bedding place (Potter and Pettijohn 1963).

In Chanderi area mostly symmetrical ripple marks are found. Symmetrical ripple marks are two- directional structures and give only the trend of the direction of sediment transport and support the unidirectional data obtained from such one - directional structures as cross bedding. These ripple marks are characterised by coarser particles in the troughs and finer particles in the crests indicating that they are formed by water.

The ripples in the Kaimur sandstone are of oscillation type but at places show sufficient asymmetry to suggest that some of them had been current ripples almost destroyed by reverse currents. These ripples tell about the movement of sediments perpendicular to the strike of ripple crests.

On the basis of ripple indices which fall in between 4 and 10, it can be suggested that these ripples were formed under aqueons canditions (Kindle and Bucher 1960).

Readings of ripple marks in Kaimur and Rewa sandstones, taken from the area appear in tables 6 and 7 .

Table 6.- Readings of Ripple marks in Kaimur sandstone.

	Amplitude		Wave Length 'L'	Azimuth	Ripple Index
1.	0.6	cm	6 cm	225°	16
2.	0.2	cm	2 cm	195°	10
3.	1	cm	8 cm	200°	8
4.	1.5	cm	7.5cm	195°	5
5.	0.8	cm	7.5cm	210°	9.4
6.	0.5	cm	3 cm	235°	6
7.	0.6	cm	2.5cm	235°	4.1
8.	1.2	cm	10 cm	170°	8.3
9.	0.5	cm	4.5cm	170°	9
10.	0.5	cm	3 cm	135°-145°	6
11.	0.8	cm	5.2cm	215°	6.5
12.	0.5	cm	3 cm	135°	6
13.	0.8	cm	5 cm	145°	6.2
14.	0.6	cm	5 cm	200°	8.3
15.	0.5	cm	2 cm	210°	4
16.	0.2	cm	2 cm	175°	10
17.	0.4	cm	2.5cm	200°	6.2
18.	0.4	cm	2 cm	195°	5
19.	0.5	cm	2.5cm	185°	5

Table 7. - Readings of Ripple marks in Rewa Sandstone.

1.	1.3	cm	11 cm	250°	8.5
2.	1	cm	6 cm	235°	6
3.	1.4	cm	12 cm	230°	8

Table 8.- Readings of Ripple marks in Rewa sandstone (Cont.)

	Amplitude	Wave Length 'L'	Azimuth	Ripple Index
4.	1 cm	5.5 cm	225°	6.5
5.	1 cm	6.5 cm	210°	6.5
6.	1.2 cm	2 cm	265°	1.6
7.	.3 cm	2.5 cm	245°	8.3
8.	.5 cm	2 cm	290°	4
9.	1.6 cm	12 cm	210°	7.5

An average direction of current obtained from the readings of ripple marks in South-East to North-West and is plotted in Fig.

PARTING LINEATION - The term parting lineation was proposed by Crowell (1955) to describe linear irregularities of low relief on bedding surface which are due to the linear arrangement of grains parallel to current direction. It is usually found in sheet like sandstone in the rocks of Kaimur group in Chanderi area. It is two way directional structure and therefore it does not give the sense of the direction of current movement but supports the data obtained from unidirectional structures. The current direction obtained from the data of parting lineation is South East to North West.

Table 9.- Readings of Parting Lineations in Kaimur sandstone.

S.No.	Readings.	Locality
1.	130°	Road coming from Sipri to Chanderi.
2.	100°	Road coming from Sipri to Chanderi.

Table 10- Readings of parting Lineations in Kaimur sandstone.

S.No.	Readings	Locality
3.	102°	At Piranpur temple.
4.	120°-125°	At Piranpur temple.
5.	108°	At Piranpur temple.
6.	110°	At Piranpur temple.
7.	135°	At Piranpur temple.
8.	230°	From Piranpur to Chanderi in a Nala cutting.
9.	255°	From Piranpur to Chanderi in a Nala cutting.
10.	265°	From Piranpur to Chanderi in a Nala cutting.
11.	270°	From Piranpur to Chanderi in a Nala cutting.
12.	205°	From Piranpur to Chanderi in a Nala cutting.

<u>CROSS BEDDING</u> - At the time of stratification some oblique lamenations are developed which are generally inclined to principal surface of accumulation and are termed cross bedding.

Cross bedding is a unidirection structure so it tells the direction of current movement and as such in palaeocurrent studies it is of much importance.

The readings of cross bedding obtained from Kaimur and Rewa sandstone are given in tables 11 and 12 .

Table 11 - Readings of cross bedding obtained from Kaimur sandstone

S.No.	Locality	Azimuth	cross bed dip amount	Unit	Scale	Dip of normal bed
1.	Road coming from Sipri to Chanderi	300°	3°	2.5"	2'	3° or Horizontal

Table11- Readings of cross bedding obtained from Kaimur sandstone

S.No.	Locality	Azimuth	cross bed dip amount	Unit	Scale	Dip of normal Bed.
2.	Road coming from Sipri to Chanderi	305°	3°	2.5"	4'	3° or Horizontal
3.	Road coming from Sipri to Chanderi	295°	3°	6"	3'	Almost low tha 5°
4.	In the valley coming from Piranpur to Chanderi	300°	3°	9"	3'	3°
5.	In the valley coming from Piranpur to Chanderi	290°	3°-5°	6"	2'	3°
6.	In the valley coming from Piranpur to Chanderi	310°	5°	6"	2.5'	3°

The azimuth of cross bedding readings obtained from Kaimur sandstone varies from 290° to 310°.

The dip of cross bed is very low and varies from 3° to 5°. The unit of cross bed varies from 0.9' to 2.5' and the scale varies from 2' to 4'.

Table13- Readings of cross bedding obtained from Rewa sandstone

S.No.	Locality	Azimuth	cross bed dip amount	Unit	Scale	Normal bed reading
1.	From Nanki to Imalia	315°	5°-6°	8.5cm	3'	Dip very low Horizontal
2.	Nanki to Imalia	308°	5°-6°	7.5cm	1'	Dip very low about 3°
3.	From Kaushak Mahal to Chanderi	308°	3°	7 cm	2.5'	Dip very low
4.	From Ramnagar to Imalia Village.	308°	3°	3.5cm	1'	About 3°

Table14- Readings of cross bedding obtained from Rewa sandstone.

S.No.	Locality	Azimuth	Cross bed dip amount	Unit	Scale	Normal bed reading
5.	From Ram Nagar to Imalia Village	315°	3°	3.5cm	1'	Dip very low
6.	From Ram Nagar to Imalia Village	295°	3°	7 cm	2'	3° dip

The azimuth of cross bedding reading obtained from Rewa sandstone varies from 295° to 315°. The dip of cross beds varies from 3° to 6°, unit varies from 3.5 cm to 8.5 cm and the scale of cross bed varies from 1 ft. to 3 ft.

As the dip of beds where primary structures occur are very low, tilt correction was not given to the cross bedding readings. Nearly 12 observations were taken from the area, six from the Kaimur and 6 from the Rewa sandstones. The observations obtained from Kaimur sandstone were plotted in circular histograms with 20° class interval. In the same way the readings obtained from Rewa sandstone were also plotted.

The vector mean of cross bedding obtained from Kaimur sandstone was calculated following the graphic method outlined by Raup and Misch(1957) which comes to 301°. The vector mean of the cross bedding obtained from Rewa sandstone was found to be 308°.

PALAEOCURRENT ANALYSIS

The importance of palaeocurrent study was first of all recognised by Sorby (1867 ,p 285) who stated that " The examination of modern seas, estuaries and rivers, shows that there is a distinct relation between their physical geography and the

ROSE DIAGRAM OF REWA SANDSTONE
SHOWING PALAEOCURRENT PATTERN

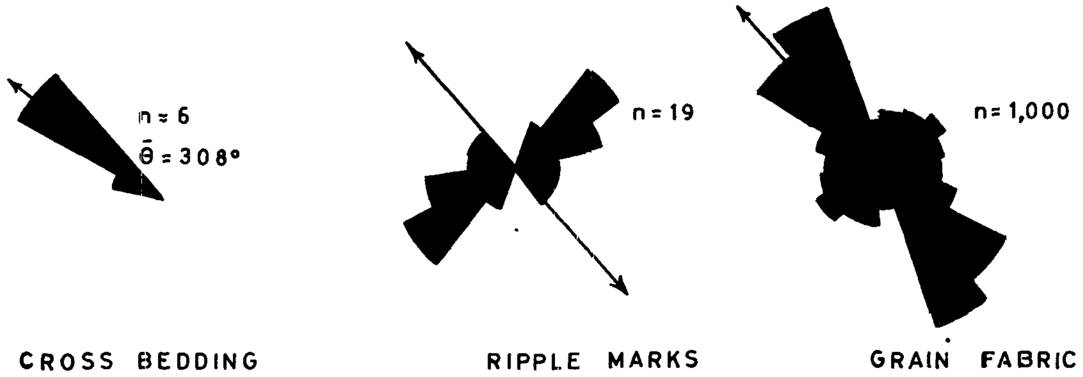


FIG. 6

ROSE DIAGRAM OF KAIMUR SANDSTONE
SHOWING PALAEOCURRENT PATTERN

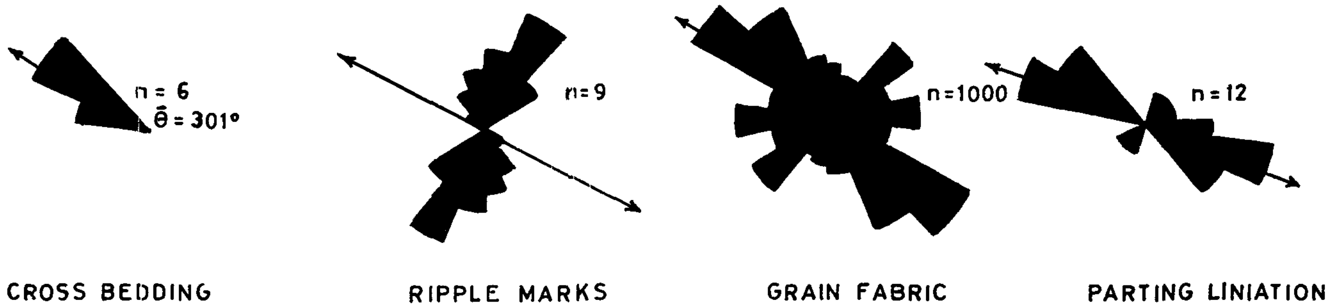


FIG. 7

current present in them; current so impress them that their characters can be ascertained from those formed in ancient periods. Therefore their physical geography can be inferred within certain limits ".

The study of palaeocurrents can be made with the help of directional primary structures such as cross bedding, ripple marks, parting lineations and grain fabric. The knowledge of these helps in determining the direction of palaeoslope, the relation between facies boundary, palaeocurrent direction and the direction of sediment supply.

The study of palaeocurrent in and around Chanderi was made with the help of the data obtained from primary structures and dimensional fabric.

The direction of dip of cross bedding is very useful in determining the palaeocurrent direction. The palaeocurrent direction obtained from the data of cross bedding azimuths has been determined and indicates a direction of sediment transport from S.E. to N.W. The direction obtained from symmetrical ripple marks also indicates a S.E. to N.W. direction. Similarly the palaeocurrent direction obtained from parting lineations and grain orientation also comes S.E. to N.W.

A review of palaeocurrent data which has been plotted on the geological map of the area, shows that palaeocurrent came from S.E. to N.W.- suggesting a provenance somewhere towards the South east. The data also suggests that the deeper part of the Vindhyan basin in this area lay towards the N.W. of Chanderi.

CHAPTER VI.

CONCLUSION.

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On the basis of present study of Rewa and Kaimur sandstones some broad generalised conclusions can be made as regards the provenance and sedimentation history of Vindhyan Rocks in and around Chanderi.

The study of provenance was made with the help of primary structures and petrographic studies of rock types met with in and around Chanderi. The primary structures, namely cross bedding, ripple marks and parting lineation along with the fabric study of different samples collected from Chanderi, point to the source area some where towards east or south east.

To determine the provenance nearly 2,000 grains of quartz were measured for their length and breadth and their ratios were calculated. From these ratios histograms (Fig. 8 & 9) were made and compared with the histograms of Bokman(1952) and the probable source area was determined.

It is clear by comparing the histograms obtained from the data, with the standard histograms of Bokman(1952), that the provenance should have been composed of medium grained metamorphic rocks and granites.

At the first sight it appears that the Bundelkhand granites may have been the source area but as the detrital quartz grain are subrounded to rounded and show two cycle history, it appears that the provenance must have been a medium grained mature sedimentary rock because such a good roundness is not possible for such a short distance of transport.

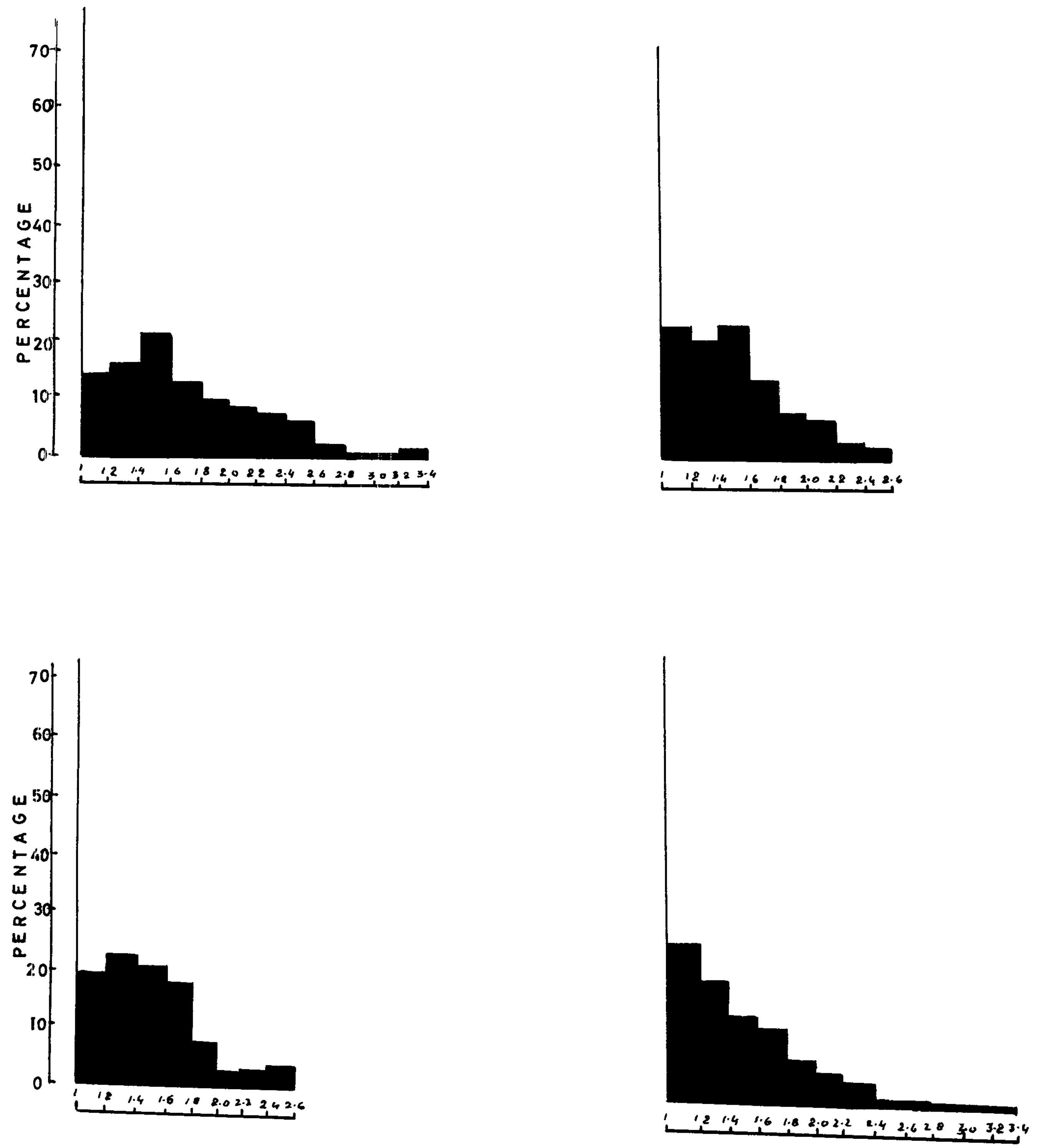

FIG. 8. HISTOGRAMS SHOWING ELONGATION QUOTIENT OF QUARTZ GRAIN IN KAIMUR SANDSTONE

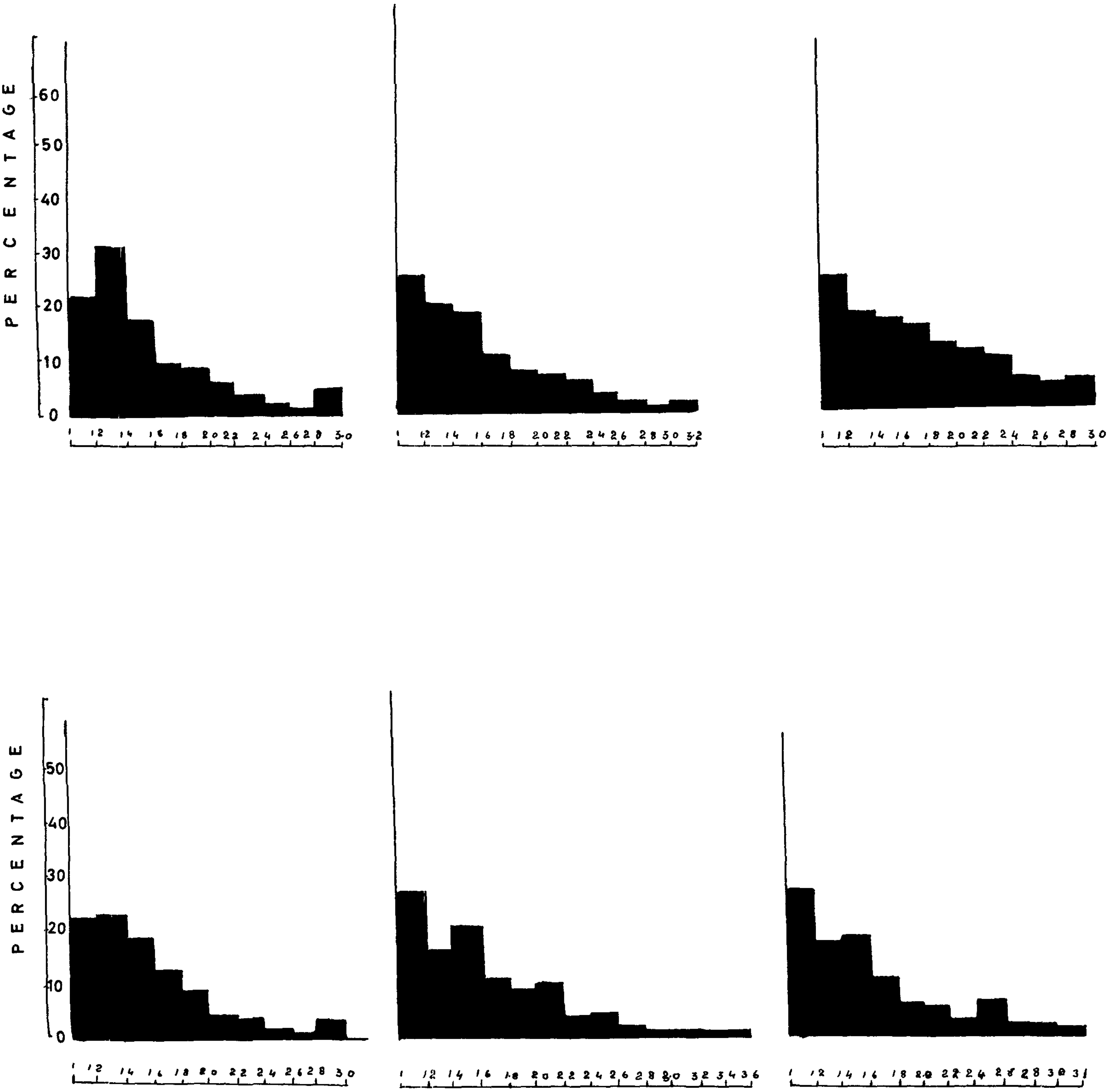

FIG. 9 HISTOGRAMS SHOWING ELONGATION QUOTIENT OF QUARZ GRAINS IN REWA SANDSTONE

It is well known that a sedimentary rock is not only a product of its provenance and dispersal history but its nature also depends on the environmental conditions of deposition. The lithology, petrography and texture of Vindhyan rocks show that these rocks were deposited in a beach environment from the material transported from the siliceous bordering regions, under a seasonal rain fall which is confirmed by the following observations:-

(1) Freshness of basement granite.

(2) Presence of felspar grains in Kaimur and Rewa sandstones.

(3) The conspicuous rounding of quartz grain.

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Plate No. 1 :- Quartz grains showing hazy boundaries and secondary silica filled in the inter--spaces.

Plate No. 2:- Regular contacts of quartz grans with secondary enlargements.

Plate No. 3:- Quartz grains showing undulose extinction and well rounded grains of chert and rockfragments.

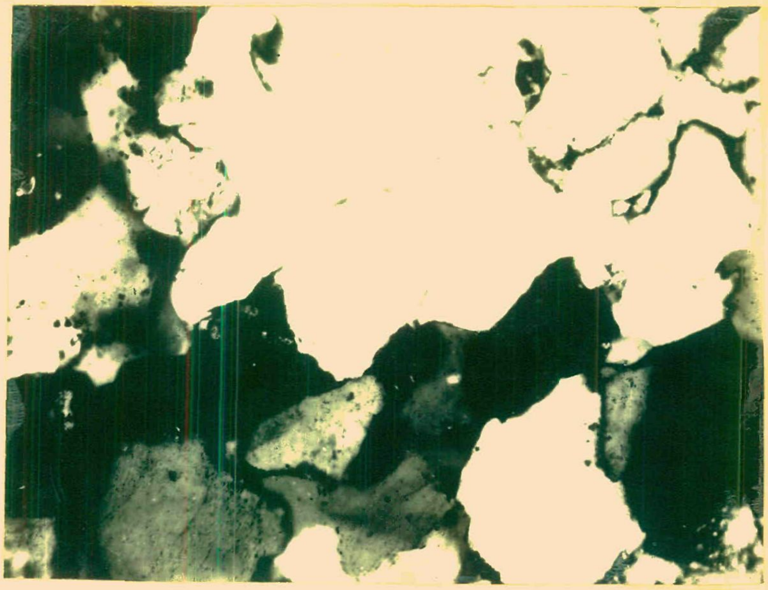

Plate 1.x 100

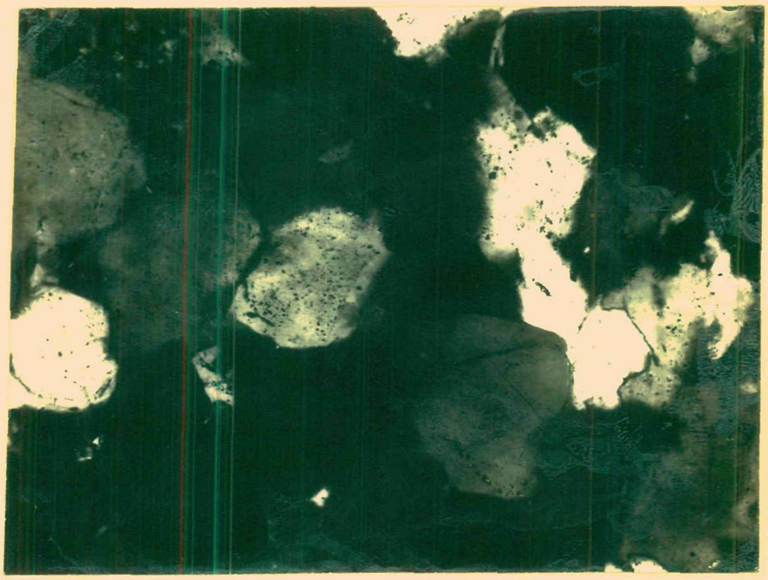

Plate 2. x 100

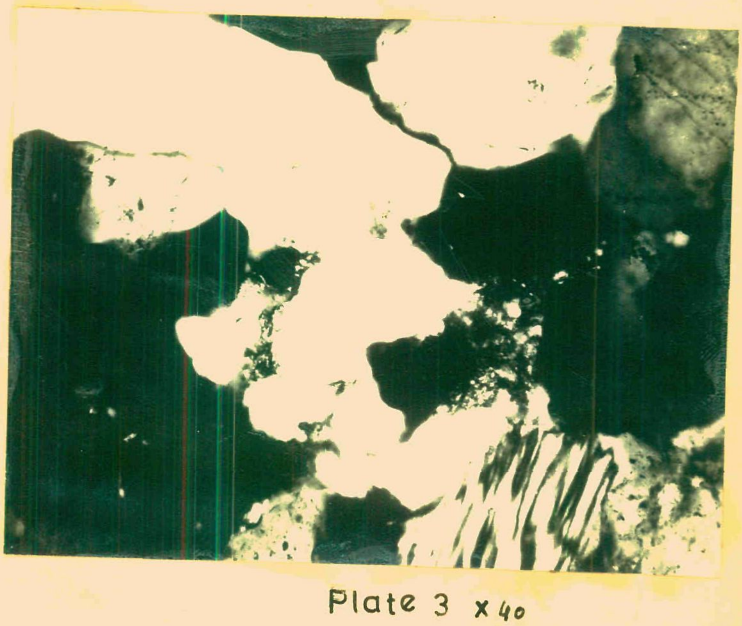

Plate 3 x 40

FIG 10

Plate No. 4 :- Grains showing irregular over growth and suture contacts.

Plate No. 5 :- Well rounded grains of quartz with dusty boundaries and feldspar showing suture contacts and secondary enlargements.

Plate No. 6 :- Big grains surrounded by smaller grains having clear boundaries and ferrugeneous cement.

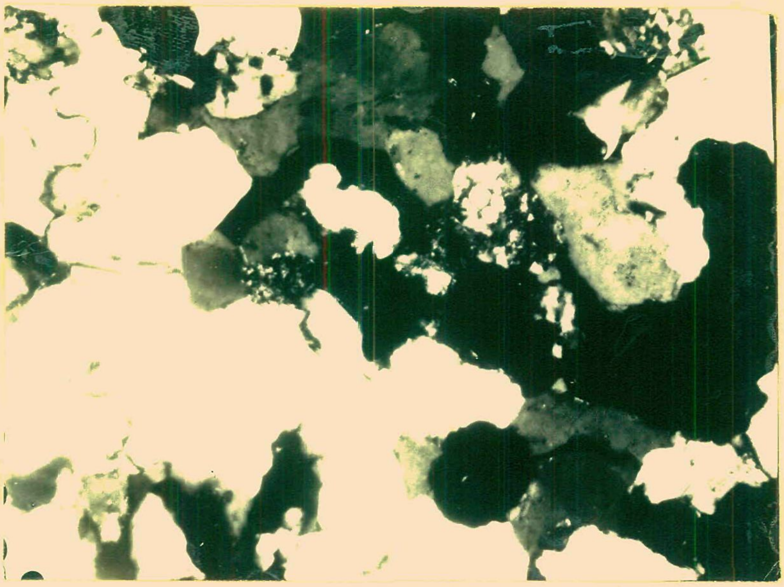

Plate 4 x100

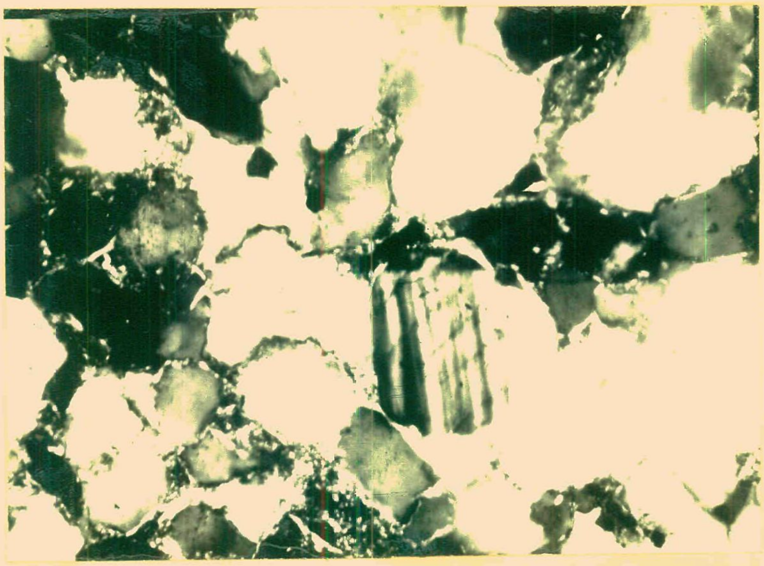

Plate 5 x100

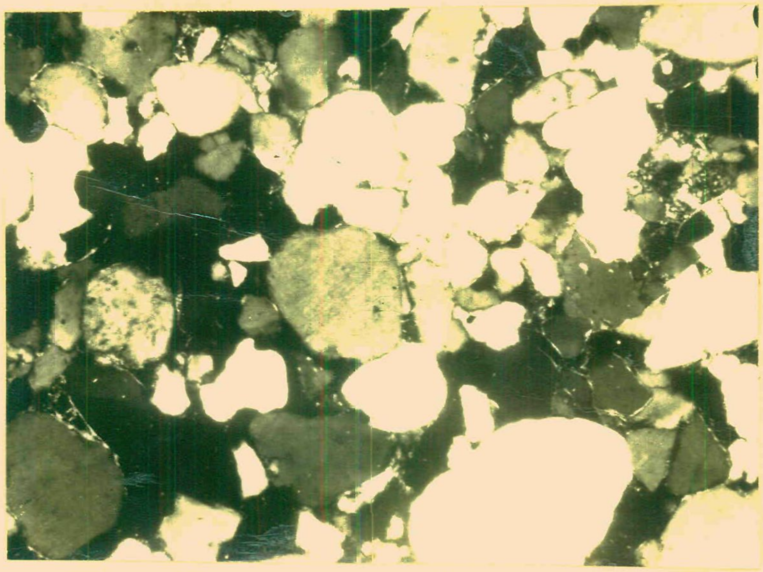

Plate 6 x100

FIG. 11